

The Drainage of Melbourne.

BY W. W. CULCHETH, M.I.C.E.

[Read 13th October, 1881.]

THE present condition of the drainage of Melbourne and the measures necessary for its improvement have attracted fresh attention by the recent award of the Mayor's prize for the best essay on the subject. The judges' selection of one essay, as the best of those that were submitted, has met with general approval; but the decision has been misunderstood as signifying approval of the scheme proposed, and it has accordingly been suggested that it should be carried out forthwith. It would be, however, very unwise to do this before the proposals have been criticised, and public opinion has had an opportunity of expressing itself on the subject. The essay possesses many merits, but is too brief to be entirely satisfactory; hence, perhaps, the proposals are liable to be misunderstood. In this paper, it is intended to give a brief outline of the scheme recommended by the essayists; then to point out some of the defects revealed by a careful perusal of both the essay and plans. To dwell only on the advantages of the scheme would not tend to call forth additional particulars, which are much required. The time allowed will not permit of the essay being thoroughly examined; its defects only can be considered just now. Perhaps some of the defects are merely apparent, due to the absence of detail; but whether apparent or real, they need to be explained or removed by further information.

2. The drainage, as dealt with in the essay, may be classed as follows:—

(a) Subsoil water.

(b) Surface drainage, consisting of—

1. Rain water flowing off roofs, court-yards, and the less populous thoroughfares.

2. Ordinary winter rainfall in the streets where there is heavy traffic, or a portion of the ordinary drainage of such streets. This may be conveniently called "street drainage."

3. Flood water in excess of the ordinary rainfall.

(c) Waste water from houses or manufactories—

1. That which is too offensive to be allowed to flow

into the street gutters, which may be conveniently termed "house drainage."

2. That which has been used for motive-power in manufactories, for cooling in breweries, and for baths, termed in the essay "harmless drainage."

The essay provides for the treatment of the above in one of two ways:—

I. Allowed to flow directly into the Yarra—Subsoil water (a); rain water from roofs, &c. (b_1); flood water (b_3); and harmless drainage (c_2).

II. Conveyed through sewers to a filtering area—Street drainage (b_2) and house drainage (c_1).

3. The proposed means for effecting the removal of the drainage are—(1) Street gutters; (2) storm-water drains; (3) porous earthenware pipes; and (4) sewers. By means of these the drainage will be collected and conveyed to its destination by the following arrangements, viz.:—

I. THE YARRA.—Subsoil water (a) to be collected by porous pipes, laid at a sufficient depth to drain house foundations and cellars, but not connected with the sewers. Rain water from roofs, &c. (b_1), and harmless drainage (c_2) to flow into the street gutters and be carried off as at present. Flood water (b_3), where the greatest accumulation occurs, to be carried off by underground storm-water drains.

II. THE FILTERING AREA.—Street drainage, where the traffic is greatest (b_2), to be admitted from the gutters into the sewers, the openings being sufficient for only a small quantity of the dirtiest water. Of house drainage (c_1), it is remarked, not one drop of offensive waste water ought to escape into the street channel; it should be intercepted and carried into the sewers.

4. It is proposed to enlarge the gutters, at the same time widening the street pavements without reducing the available carriage way. The only storm-water drain provided is in Elizabeth-street, which is spoken of as the most important locality to be dealt with. Subsoil water, collected by porous earthenware pipes, is to be allowed to escape into the Yarra at as many points as convenient; but it is remarked that it will not be possible thoroughly to drain cellars in some portions of the area, owing to their low level, except by pumping. Arrangements for pumping this water do not, however, appear to be included in the scheme. It is particularly pointed out that the subsoil drainage pipes must not communicate with the sewers.

5. The system of sewers is arranged to convey all the sewage to the pumping station "in the sandy ground west of Sandridge." Here the sewage "will be pumped up on to a sloping perforated platform, from which the more solid substances can be readily collected and carted away, while the liquid portion of the sewage will pass through the perforations into carriers, which will take it" to the filtering beds. The filtering area is to consist of "three divisions, each of about forty acres, laid out with open drains running in the direction of the out-fall, and drained not less than six feet deep with agricultural tile drains." The area for the present considered sufficient is 120 acres; but 200 acres more, or 320 acres altogether, are provided to meet an increase of the population up to 500,000. For pumping the sewage, "the engine-power required at present will be, including a reserve in case of accident, an engine of 53-horse power, and one of 26, and three centrifugal pumps, each capable of throwing 6100 gallons per minute 15 feet high."

6. The localities dealt with are, with the exception of some thinly populated portions, Melbourne City, Fitzroy, Collingwood, Richmond, Prahran, St. Kilda, Emerald Hill, and Sandridge. Provision is made for connecting Hawthorn, if required. The area included is not stated. The present population of these localities is, probably, about 200,000; but it is remarked the main works are sufficient for an increase of the population to 500,000. The pumping machinery is limited to what is required at present, facilities being afforded for connecting additional engine-power when required.

7. The approximate cost of the works to be carried out first, in the streets, at the pumping station, and in preparing the filtering area, is £275,000. The total ultimate cost of the whole scheme sufficient for a population of 500,000, is estimated at £336,250. The storm-water culvert in Elizabeth and Little Bourke streets is to cost £26,512 in addition. It is, however, remarked that it is impossible, from the data supplied, to give anything like an exact estimate. The annual cost of pumping is put down at £900 at first, and at £1850 ultimately. No other working expenses are mentioned.

8. Such is an outline of the scheme proposed in the essay. Reasons are given for coming to certain conclusions on a few main points only, such as—(1) the necessity for subsoil drainage, (2) removing a portion only of the rainfall by the

sewers, (3) recommending the introduction of water-closets in place of the dry-earth system, (4) the selection of a site for the final disposal of the sewage, and (5) dealing with the sewage by the system known as "intermittent downward filtration." But even on these points the information is very meagre, and the data on which the results generally are based are not given; it is, consequently, often very difficult to make out what the essay really allows for various purposes.

9. In criticising the essay it will be well to commence with the estimate of probable outlay for the works, which is one of the first things to attract the attention of the public, who will have to find the money. The estimate cannot be criticised in detail, but the total sum may usefully be compared with the cost of works executed elsewhere. The cost of the main drainage of London was "£1, and its annual expenses 1s., per head of the population;" and it has been remarked that "these figures contrasted most favourably with the primè and annual cost of any other system in use," in England or elsewhere.* The drainage of Paris probably cost about £2 a-head.† It would not be surprising, therefore, if a complete and efficient scheme for Melbourne should cost more than stated in the essay; the ultimate cost allowed being only two-thirds of the London rate.

10. Pumping is the only item of annual working expenses mentioned in the essay. There is, however, much else to be allowed for, such as—(1) wear and tear of machinery, (2) repairs to sewers, traps, gratings, and works of all kinds, (3) flushing the sewers and clearing out obstructions now and then, and (4) removing the sludge from the gratings at the filtration area, and digging it into the ground. The interest on a loan must also be provided, as well as a certain sum for the repayment of the loan. Then there would be the establishment required to enforce the rules that would have to be adopted, and to superintend generally the working of the scheme; a certain office establishment would also be necessary. A drainage scheme cannot be left to each local authority to do what it pleases; there must be one central authority over the whole; this, indeed, the essay insists on. As above remarked, the annual expenses of the drainage of London amount to 1s. a-head; the drainage of Paris costs still more. At 1s. a-head, the annual cost in Melbourne for

* "Proceedings of the Institution of Civil Engineers," vol. 49, p. 219.

† *Ibid*, vol. 53, pp. 193, 201.

the existing population of 200,000 would be about £10,000, instead of £900 only, the sum provided in the essay. If it be urged that the sum of £900 is, as stated in the essay, for pumping only, not one of the numerous other items just mentioned is provided for.

11. The next point that may be considered is the engine-power allowed for pumping. The work to be done by the three pumps is to raise 18,300 gallons—equal to 183,000 lbs.—per minute to a height of 15 feet, or 2,745,000 foot-pounds per minute. One effective horse-power being represented by 33,000 foot-pounds per minute, it is clear that the *effective* power required is that of over 83 horses. Adding one-fourth to cover loss by friction, &c., the result is that 104 horse-power engines ought to be provided, instead of 79 only. Professor Rankine's rule* gives the same result. The point is, perhaps, chiefly a question of the definition of terms; one manufacturer asserting that his engines are capable of doing more work than that expressed by their nominal horse-power. Whatever pump-makers may, however, promise on behalf of their machinery, it would be only prudent to make a considerable extra allowance for safety. In any case, the question could be settled by adding to the amount of the estimate.

12. A very important point in any drainage scheme is how the sewage is to be finally disposed of. The locality selected in the essay for Melbourne is a portion of the Sandridge Flat. It is little more than two miles from the heart of the city in a south-west direction; and it is due west of Sandridge and Emerald Hill, close to the former and about a mile and a half from the latter place. As the wind blows from one or the other of these two points for nearly a quarter of the year in an average season, it is most important that there should be no doubt as to the area being sufficient and suitable for purifying the sewage at all times, without the risk of being offensive in any way. Yet it is scarcely possible to inquire into the provision made in the essay for this part of the scheme without serious misgivings.

13. The area said to be at present required is 120 acres, formed into three divisions of 40 acres each; one division to be in use for four months or longer, while the other two divisions are being cultivated. It is suggested that irrigation

* Rankine's *Civil Engineering*, p. 734.

should be encouraged; but the sewage farm mentioned in the essay is apparently considered a matter of secondary importance, being chiefly intended for the disposal of the sludge collected by the strainers. Only a very small portion of the sewage could be used for irrigation at this farm, and that in dry weather merely. Since, therefore, no special provision is made for irrigation on a scale sufficient to affect the result, the 120 acres of filtering beds must be capable of purifying the whole of the sewage.

14. The case of Merthyr Tydvil is referred to in support of the recommendations made in the essay. But Mr. Bailey Denton, by whom the arrangements there were designed in 1871, wrote six years afterwards, that, *for a time*, 20 acres of land sufficed at Merthyr for the purification of the sewage from a population of 30,000 persons,* or 1500 per acre; and he believed purification by the same process "could have been assured for a permanency by the use of 75 acres,"† which would give 400 persons to the acre. The population of Melbourne being taken at 200,000, and an area of 120 acres being provided for the permanent purification of its sewage, the average is 1667 persons per acre, instead of only 400, as at Merthyr; while for the four months that the sewage would be flowing on to 40 acres only, each acre would have to purify the sewage of 5000 persons, instead of only 1500, as at Merthyr.

15. Again, if the quantity of sewage to be dealt with is considered, the filtering area still appears to be inadequate. The quantity of sewage is nowhere definitely stated in the essay; the only information on the point is furnished in the statement of the work the pumps are required to do. Supposing two of the three pumps (leaving one as a reserve), each raising 6100 gallons a minute, to be working, the quantity of sewage to be disposed of would be 17,568,000 gallons—equal to 2,810,880 cubic feet—in 24 hours. This poured over 40 acres, or 1,742,400 superficial feet, would give a depth of over 19 inches to be absorbed daily. This certainly would be in wet weather only; the dry weather discharge might be half this, or a depth of nearly 10 inches. The average of the year may be taken at one pump working every day, and a second pump every third day only; this would give a little over one foot daily to be absorbed. My own experi-

* Bailey Denton's *Sanitary Engineering* (1877), p. 327.

† *Ibid.*, p. 329.

ence with irrigation in India would show that no culturable soil could absorb anything like so much pure water even, day after day. Sand might perhaps absorb this quantity of water, but not so much sewage for a continuance, I should say.

16. Again, the depth of soil through which the sewage is to pass being 6 feet, giving 9680 cubic yards of soil per acre, from $22\frac{1}{2}$ to 45 gallons of sewage, or an average throughout the year of 30 gallons, would have to be purified daily by each cubic yard of soil. On this point, Mr. Denton states that soil has a cleansing power varying from 4 to 12·4 gallons of sewage per cubic yard per diem. Dr. Frankland, who made some experiments for the Rivers Pollution Commissioners, stated before the Institution of Civil Engineers that the average result obtained by him was 9·6 gallons per cubic yard in 24 hours. In one case a good soil purified so much as 15·2 gallons for a time, but there were indications that it would not keep up this high rate; while another soil failed entirely to purify sewage; sand purified 5·6 gallons per cubic yard.* These results (which, it should be noted, were obtained in the laboratory, and are, therefore, more favourable than can be expected in practice) are very different from the 30 gallons per cubic yard to be purified at the filtering area provided for Melbourne, according to the particulars given in the essay.

17. Comparing, then, either the area provided in the essay with the population, or the quantity of soil with the volume of sewage to be purified by it, and taking as an example the case of Merthyr Tydvil (which is referred to in support of the recommendations made in the essay), the filtering area provided for Melbourne appears wholly inadequate. Mr. Denton recommends, where suitable land can be obtained at a fair price, the sewage should be disposed of ordinarily by irrigation, and that an area for intermittent downward filtration should be added as a kind of safety valve. In this way only, he considers, the loss which is inseparable from any other mode of disposing of sewage, "may be turned into a profit."† He says one acre for 1000 persons should be set apart for filtration, out of one acre for 100 allowed for irrigation.‡ This would give, for a population of 200,000, an

* "Proceedings of the Institution of Civil Engineers," vol. 48, pp. 192, 193.

† Bailey Denton's *Sanitary Engineering*, p. 339.

‡ *Ibid.*, p. 340.

area of 200 acres for filtration, in addition to 1800 acres for irrigation; whereas the essay provides 120 acres only for the one process alone.

18. But there is yet another question which concerns the proper filtration of the sewage in the locality selected, even if a sufficient area should be taken up—How far is the level of the land suitable? Drains are to be laid six feet below the surface, and these drains must be sufficiently above the water level of the bay to admit of the effluent water flowing off at all times, besides allowing a slope in the drains themselves to give the requisite discharge. Is the ground high enough for this? If it is not, it could certainly be raised to the required level; but does the estimate provide for this? A sum of £2500 is shown as the cost of preparing filtering ground, equal to nearly £21 an acre for the 120 acres at first required. According to a report by Mr. Rawlinson, “the works at Merthyr cost £230 per acre, while those at Kendall cost £280 per acre.”* On what data then is £21 an acre considered sufficient in the case of Melbourne, not only to underdrain the land and prepare the surface, but also to raise it?

19. With regard to the sewers, a few remarks may be now usefully made. It is stated in the essay—“The smaller street drains, being designed to carry off the sewage immediately, before it has time to become putrid, do not require flushing in general, but they should be washed out occasionally by turning on the Yan Yean water into them to assist the ventilation.”† Flushing would thus seem to be considered necessary to remove putrid matter only, and not solid substances generally, putrid or otherwise, which are liable to lodge in drains. It is usually found that, as the flow of sewage in the smaller drains and sewers is intermittent, they are particularly liable to be stopped up by paper, hair, grease, &c., and that frequent flushing is necessary.‡ Water from baths is especially suitable for flushing house drains and the smaller sewers to remove these obstructions, since it flows off in a rush; yet the essay says it is not to be used. It is also most plentiful in summer, when Yan Yean water from the mains can least be spared, and flushing is most required.

* “Proceedings of the Institution of Civil Engineers,” vol. 48, p. 246.

† See paragraph 31 of the essay.

‡ Baldwin Latham’s *Sanitary Engineering* (1878), pp. 184, 286, and 482.

20. The importance of frequent flushing not being recognised, the absence of the allusion to the gradients of the sewers leads one to doubt whether this point has received full consideration, especially as it is remarked in one place—"Melbourne has for the most part favourable gradients for the employment of small sewers," and again, "the sewage will flow away wherever the ground is sufficiently inclined. In general, there is ample 'fall to secure this.'"^{*} The only misgivings as to the slope obtainable generally, are expressed in the remarks made regarding the special treatment proposed for certain flat areas; this treatment will be examined in the next two paragraphs. To explain what the sewers are capable of doing, the gradients to be given to them are necessary to be known, as well as their sizes; the essay gives the sizes only. The efficient and economical working of the system, as well as much of the comfort of the inhabitants, will depend largely on sufficient gradients being given to the sewers, particularly to the smaller ones.

21. Where the slope of the ground is very slight—Richmond Flat, Collingwood, head of Wellington-street, and part of Sandridge are specially named in the essay—it is proposed to use cast-iron pipes, the contents of which might be forced "into the main sewer once or twice a day by hydraulic pressure from the water main, the house sewers being fitted with reflex valves."[†] It would be interesting to know the details of the proposed arrangement, where it has been tried, and how it has been found to answer. If it is intended to connect the water main with the sewer in order to obtain the hydraulic pressure mentioned, this arrangement is open to the very serious objection, that the water in the main would be thereby liable to contamination occasionally by sewer gas. In any case, Yan Yean water would be required, and, apparently, a considerable quantity of it, to work this system.

22. These cast-iron sewers are not, however, to be introduced till the localities named become more populous; for the present, it is proposed that the house drainage should continue to flow into the gutters, and be swept into the main sewer by manual labour. This would not be much of an improvement, if any, on the existing state of things; and it is not likely to be satisfactory to the ratepayers of the

^{*} See paragraphs 6 and 14 of the essay.

[†] See paragraph 44 of the essay.

localities to be so treated. Some better plan, surely, might be devised. Why should certain places, "the natural direction of the drainage" of which is not "unsuitable," be omitted from the general system "because the sewer levels would be too low to be directly connected with the main sewer"?* If one locality is too poor of itself to pay for exceptional or additional measures being taken for its efficient drainage, other localities ought to contribute. It would not be to the advantage of the wealthier and more favourably situated localities to have in their midst imperfectly drained places—hot-beds of disease, due to bad drainage. The drainage of Melbourne and its suburbs must be treated as a whole, and difficulties properly met, not avoided.

23. The openings to admit to the sewers a small quantity of the dirtiest water from the streets, whenever rain falls, are placed at the bottom of the street gutters. The principle by which the admission of this water is to be regulated requires explanation. On the one hand, the drainage of streets where there is much traffic is found to be as foul as the worst sewage, consequently, ample provision for passing it into the sewers is necessary; on the other hand, unless the sewers are of sufficient capacity, they are liable to overflow in long-continued wet weather, and to flood low-lying yards and streets. Merely trapping house drains would not prevent this serious evil. Further, what is to prevent much of the street grit, which the essay remarks should be excluded, from being washed through these openings into the sewers?

24. Owing to the limited time allowed for reading this paper, a few other points will be only just noticed by one or two questions:—(1) What are the respective quantities of house and street drainage the sewers are designed to carry? The only information as to the volume of sewage to be dealt with is contained in the statement of the work for the pumps to do. (2) Is the remark in the essay, "that the sewage cannot be brought to any filtering ground by gravitation," borne out by the levels given on the plans as regards the higher parts of Melbourne? Owing to all sewage having to be pumped, much has been excluded from the sewers that might be admitted with advantage, such as water from baths and from court-yards. (3) What provision is made for getting rid of that portion of the subsoil drainage, which the essays says,

* See paragraph 19 of the essay.

owing to the cellars being too low, would have to be pumped up? (4) As regards flood water, is the 30,000 cubic feet* mentioned in the essay, the whole or only half of the flood water provided for? From what area is this to be collected? Is the discharge calculated at 15 cubic feet per acre per minute, which the essay says would flow off in very heavy rainfall? This would give only a quarter of an inch of rain per hour—not much to allow for a heavy thunderstorm.

25. The following summary will show at a glance the chief points alluded to in this paper:—

- (1) No provision made for pumping subsoil water from places too low for it to flow into the river.
- (2) Pumping-power for sewage deficient by about 25 per cent.
- (3) Absence of the means of *regulating* the admission of street drainage to the sewers.
- (4) No provision made against the danger of sewers in places overflowing in long-continued wet weather.
- (5) Importance of *frequently* flushing the sewers not recognised.
- (6) Yan Yean water to be used *occasionally* for flushing, while water from baths, which is most suitable for the purpose, is not to be used.
- (7) Inadequate provision made in dealing with certain flat areas in the suburbs.
- (8) Filtration area too small, considering the population and the quantity of sewage to be dealt with.
- (9) The case of Merthyr Tydvil fails to support the recommendations of the essay.
- (10) Level of land selected appears to be too low for the effluent water to flow off freely.
- (11) Estimated cost of preparing the land appears extremely low.
- (12) Probability of both the first cost of the whole scheme and of the subsequent annual charges exceeding considerably the amounts stated in the essay.

26. Although so many defects have been brought to notice above, I do not wish it to be understood that I think there is a want of merit in the prize essay. I heartily approve of several of its recommendations, and only regret that time will not allow of its favourable, as well as

* See paragraph 25 of the essay.

unfavourable, points being noticed. The object of this paper is, by calling forth a discussion on the subject generally, but more particularly to the points above noticed, to lead to further information being obtained, and a clearing up of all difficulties. Some of the difficulties can, doubtless, be easily explained when the key is once given; but at present the key is wanting, and, in consequence, the scheme proposed in the essay *now appears* very incomplete. If I can be shown to have misrepresented the essayists, I shall be glad to correct my remarks. Some of the defects pointed out in this paper could be removed simply by an addition to the estimated cost of the works; but to get rid of others would involve material modifications of the scheme proposed in the essay. A satisfactory and efficient scheme will be devised only when there appears a decided wish on the part of the public to have one, and a determination to overcome the difficulties which are now in the way. It is to be hoped, therefore, that the discussion now invited will serve to keep public interest alive to the importance of the subject.

*On the Sea-cell as a Possible Source of Danger in
Torpedo Experiments.*

BY H. MOORS, ESQ.

[Read 13th October, 1881.]

ONE of the results of the late unfortunate accident at Queenscliff, whereby a boat's crew was destroyed through the premature explosion of a torpedo, has been to bring into considerable prominence the current from what is known as the sea-cell, and the possibility of its being a source of danger in torpedo experiments. When the cause of the accident was being keenly discussed by all who were interested in or conversant with the subject of electricity, the sea-cell current was naturally spoken of, and this was more particularly the case after it had been satisfactorily established by the Board appointed to inquire into the circumstances of